COMMUNITY-BASED CONSERVATION IN EAST AFRICA: A CASE STUDY OF NDARAKWAI RANCH, TANZANIA

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ABSTRACT

In East Africa, areas of interspersed savanna and woodland between large preserves, such as National Parks, act as important corridors for migrating wildlife. Ndarakwai ranch serves as a wildlife corridor, in particular for the African elephant (*Loxodonta africana*). We compared browsing intensity on two species of *Acacia* by measuring elephant damage in 2002 and 2004, especially as it relates to the proximity of individual trees to a permanent water hole. We found a significant negative correlation between damage to both *A. tortilis* and *A. mellifera* and their distance from the water hole, as well as significantly greater damage on *A. mellifera*. The use of this wooded site appears to have declined, as measured by the significantly lower abundance of elephant scat on the site in 2004 compared to 2002.

I. PHYSICAL DESCRIPTION OF REGION

Ndarakwai Ranch is located approximately 2 degrees 58 minutes south to 3 degrees 1 minute south by 36 degrees 58 minutes east to 37 degrees 2 minutes east in northeastern Tanzania. It is approximately 30km west of Mt. Kilimanjaro and 50km Northeast of Mt. Meru. To the south 60km is the Mt. Kilimanjaro International Airport and to the north 40km is the Kenya Tanzania border. Ndarakwai acts as a game corridor for migratory animals between three National Parks: Kilimanjaro NP, Arusha NP, and Amboseli NP. There are several villages in close proximity including, Tinga Tinga 5km to the west, Lariboro 30km to the west, and Engare Nairobi 20km to the east.

Ndarakwai offers several types of topographic features and associated vegetative cover. Plains at an approximate elevation of 1200m ASL dominate Ndarakwai. However, it also has numerous small to large hills and eroded volcanic craters that dot its landscape. The local relief of these hills and craters is between 50m and 300m, the high point of which is the formerly volcanic peak of Lobi Lokun at 1504m ASL. The plains at Ndarakwai display several types of vegetation ranging from large savanna grassland, to scrub savanna, to acacia woodlands. The hills and volcanic craters, notably, are almost exclusively scrub savanna and acacia woodlands. Forest distribution appears to be associated with topographic form in that high rolling topography offers a moister environment conducive to growth of more than seasonal grasses, while the plains are more sparsely populated with trees.

Ndarakwai's hydrological features range from seasonal riverbeds and tributaries, to man-made water holes and their feeds. The Simba River is the only perennial water source. It stems from the rain and melt waters of the glaciers on Mt. Kilimanjaro. The seasonal rivers cut deeply incised korongos, or ravines, across the plains. There is evidence that the seasonal riverbeds have meandered over time creating wider banks, terraces, and oxbows at certain points along the korongos. There are several man-made water holes at Ndarakwai, only one of which is perennial and fed by diverted water in excavated channels from the Simba River. The rest we must assume are fed by directed rainfall in the wet season.

Soil types at Ndarakwai range from powder like dust to boulder-size volcanic rocks. The soil was formed in a relatively thin layer on top of volcanic rocks. In some areas, the korongos cut deep into the soil revealing layers of volcanic ash, sediments and even a conglomerate. The layers ranged from shallow, being less than 1cm thick, to thick, being >10cm. Sand, pebbles, cobbles and boulder-sized rocks were all seen throughout the layers.

II. INTRODUCTION

Ndarakwai Ranch, located in north central Tanzania, serves as a wildlife corridor between Amboseli National Park to the north in Kenya, Arusha National Park to the southwest, and Kilimanjaro National Park to the southeast. Ndarakwai Ranch and adjacent Rafiki Farm are comprised of 10,000 and 6,339 acres, respectively, as a sanctuary from poaching as well as a permanent water source created by a diversion of the Simba River. The dominant tree species in Ndarakwai are *Acacia tortilis* and *Acacia mellifera*, the two preferred dry season tree species by the African elephant (*Loxodonta africana*). Elephants are opportunistic feeders causing significant tree damage while browsing on up to 150kg of woody tissue per day (Estes 1991). The elephant is the first species in the succession of migratory animals (Western 1997), migrating north to Amboseli National Park during the dry season to a permanent spring fed swamp, and south during the wet season following the onset of the rains (Western 1997). As the elephants move south they convert *Acacia* woodlands into open grassland, which provides adequate grazing for ungulates.

Due to the permanent water source located within Ndarakwai, we hypothesize that there is increased elephant activity around the watering hole causing *Acacia* woodland degradation. The study presented in this paper is a follow up of a study completed two years ago by Lofstedt et al. (2002), looking at the deleterious effects of elephants on *Acacia* woodland that may be associated with a permanent watering hole.

III. METHODS

The studies were conducted at Ndarakwai Ranch during the dry season from 13-17 July 2004. Two sites were selected with six transects in each site. Transects were constructed at 170 degrees from north and parallel to each other. Transects were staggered in such a fashion so that there was no interference with a nearby riverbed. Each transect was 200m in length and divided into 20m intervals. The first site was established 50m from the water hole and included 6 transects with 50m spacing. Site two was constructed in the same manner beginning at 600m away from the water hole.

Along each transect, scat identification and abundance were recorded within each of the ten 20m segments. Scat was counted if found within a 6m belt with the transect line as the center. With this sampling regime, we generated ten replicate samples per transect for a total of 120 replicates.

Elephant damage was measured at 40m intervals along the same transects described above using a modified point center quarter method. Quadrants were created at each point using a perpendicular line to the transect line. At each center point, the nearest tree of at least 1m in height was rated in each of the four quadrants. An index of elephant damage on a scale from 0 – 5 was used as follows: 0= 0% damage, 1 = 1-25% damage (some stems broken but little major damage), 2 = 26-50% damage (some damage to major stems and approximately half the smaller stems destroyed), 3 = 51-75% damage (significant damage to major stems but likelihood that tree will survive), 4 = 76-99% (sufficient damage to major stems to jeopardize the recovery of the tree), and 5 = 100% (sufficient damage to cause 100% probability of mortality). The sampling scheme used was repeated from the previous study with an additional four transects added to fill the gap between site 1 and site 2. Twenty four trees per transect were evaluated for a total of 384 trees.

Within the added 4 transects an additional sampling was conducted to investigate a preference among the dominant *Acacia* species. Transects were 210m in length with sample points at 30m intervals. On both sides of the transect, the closest *A. tortilis* and *A. mellifera* were assessed for elephant damage. A t-test was employed to test whether one species sustained significantly more damage than the other.

We analyzed the data by regression analysis, investigating damage as a function of distance from the water hole.

IV. RESULTS

The census indicated that elephant scat was most abundant followed by zebra, impala, dik dik, baboon and giraffe, respectively (see table 1). Comparing previous years scat totals with the current totals collected from the same transects, a T-test revealed a significantly greater scat abundance in 2002 compared to 2004 ($t = 2.20$, P-value = 0.05, df = 11, mean transect total 2004 = 26.25, mean 2002 = 39.9).

Table 1. Total scat count recorded for previous and current study conducted at Ndarakwai Ranch, Tanzania during the dry season. Sampling occurred July15-16, 2004.

Year	2004	2002
Elephant	363	479
Impala	258	314
Zebra	274	258
Baboon	7	34
Dik-Dik	17	63
Hyena	0	3
Jackal	0	14
Giraffe	3	10

Elephant damage showed a significant negative correlation between the degree of damage and the distance from the water hole (R-squared = 0.84, P = <.0001, R= 0.917, df =30, see figure 1).

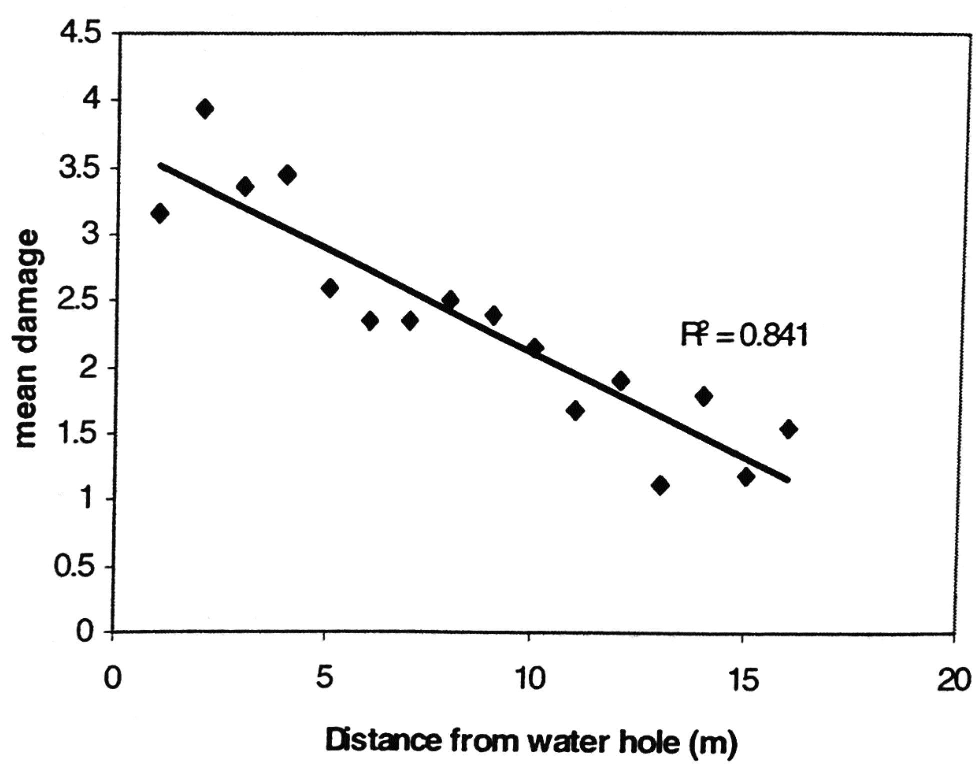

Figure 1. Mean elephant damage per transect vs. distance from permanent water hole within Ndarakwai, with decreasing damage as distance increases. Sampling dates July 15-16, 2004 (R-squared = 0.84, P = <.0001, R= 0.917, df =30). Transect 1 is 50m from the water hole and the remaining transects are at 50m intervals farther from the water hole edge.

We found that 97% of tree species were *Acacia*. Of these *Acacia*, 73% were *A. tortilis* and 27% were *A. mellifera*. The mean damage of *A. tortilis* was 2.203

and was significantly greater than the mean damage of 2.968 for *A. mellifera* (P-value = .00069, t-stat = 1.998, df = 63).

V. DISCUSSION

Lower elephant scat densities found in 2004 suggests that the increased damage may be degrading the quality of forage. We suggest that selection for watering points occurs less frequently than does diet or community selection (Senft et al. 1987) and therefore may be an underlying factor for the decrease in scat abundance. It is possible that the forage at Ndarakwai is decreasing in suitability which may explain the reduction of scat abundance for all target species. This decline may also indicate that grazing has surpassed optimal levels of forage sustainability. At the plant scale, maximum growth is achieved at low to intermediate grazing intensities (Senft, et al. 1987). Although abundance of elephant scat was down from 2002, elephant scat was still the most prevalent of all species' scat. In addition to a release from illegal poaching threats, the water hole serves as a main attraction for these opportunistic feeders. Due to the year-round resource, the lack of photosynthetic material may not deter elephants from the area for there may well be suitable quantities of woody tissue nearby.

The increased damage may have resulted from several factors, contributing to habitat degradation. Abandonment from lower quality habitats due to dry season effects, increased traffic, and foraging in close proximity to the water hole all may contribute to the decline in habitat suitability close to the water hole. Due to lack of rain in the dry season, previously suitable habitats become less favorable, sending elephants in search of more preferred areas, leading to an increased concentration of individuals in Ndarakwai. This influx of individuals is compounded by a possibility of an existing resident population. The water hole serves as an epicenter for activity leading to increased damage which is negatively correlated with distance from the water hole. Central place foraging states that where non-food resources such as water are highly localized, and forage resources are dispersed, these localized sources of water will be the main constraints for regional movement (Senft et al. 1987). On a more local scale distant vegetation may not be visible and animals would incur energetic costs for travel to other feeding sites, hence greater damage due to feeding activity in close proximity to the water hole.

A. mellifera sustained significantly more damage than *A. tortilis*. Some explanations for this phenomenon include smaller stature than *A. tortilis*, and overall plant morphology including thorn size. *A. mellifera* is more shrublike and the whole plant is accessible to elephant herbivory. This tree produces thorns characteristic of the genus *Acacia*, although noticeably smaller, and lacks secondary thorn which is present on *A. tortilis*. This may increase palatability of this species for elephants and suggests a possible reason for preference.

The preference for *A. mellifera* may lead to the disappearance of this woodland species leaving behind a monospecific stand of *A. tortilis*, forcing elephants to shift their browsing behavior towards *A. tortilis*. A possible cascading trophic effect could result within *A. mellifera*-dependent species if it is reduced or eliminated from this or other nearby *Acacia* woodlands. The increased elephant foraging pressures on *A. tortilis* and subsequent decline may lead to converting Ndarakwai into a solely seasonal area of forage suitability, at least on local woodland patch scales. Since elephants are known to convert woodlands into grasslands, the same may occur at Ndarakwai. This may, in turn, restrict the use of Ndarakwai by grazers to the rainy season when high quality grass would be available. If Ndarakwai loses its year-round animal diversity this may have deleterious effects on the ecosystem function, tourism industry and the local economy. Subsequent studies should be conducted to evaluate the ecosystem health to prevent the loss of wildlife and the livelihood of indigenous peoples.

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